The Natural Environment and the Livelihoods of People Living in a Mountainous Region of Lesotho

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ABSTRACT Lesotho is a mountainous country in southern Africa where the indigenous people practice both crop cultivation and pastoralism. This paper describes the relationship between the natural environment and the agro-pastoral land use of the region. To precisely clarify the relationship between land use and the natural habitat, the local ecosystems near a village in eastern Lesotho were examined in detail for 6 months. Temperature, soil and landform surveys were conducted. The characteristic landscape of the site was a terrace formation at about 2,500m above sea level. Settlements were located horizontally along the 2,600m contour line, separating the steep slope of the mountain and the gentle slope of the terrace. Three distinct land use patterns, each with unique environmental characteristics, were identified: cultivated fields, pastures, and settlements. In cultivated fields, the types of crops cultivated and the average temperature differed according to location. Pasture areas had the most extreme maximum and minimum temperatures, and minimal soil depths. Settlements were located above a cold-air lake that formed nightly, and here the diurnal range of temperatures was the least, indicating relative comfort in these areas.

Key Words: Mountainious region; Livelihood; Land use; Agro-pastoralism; Lesotho.

INTRODUCTION

The natural environment in a mountainous area can best be characterized by its diversity. For example, the broad range of altitudes and slope directions can result in differences in temperatures, and varying rates of erosion lead to a variety of landforms. Steep slopes, cold weather, and snowfall present environmental constraints to people living in such regions. Pawson & Jest (1978) reported that certain regions in the Andes Mountains, Ethiopia, and Tibet have the most populated highland areas in the world above 2,500m. Not coincidentally, many studies have been conducted in these regions. Researchers have also compared the adaptations and livelihoods of inhabitants in different mountain systems (Brush, 1976; Uhlig, 1995).

One of the most popular approaches to studying the relationships between the natural environment and the human population is to focus on the use of the land. Land use is defined as how local residents apply the features of their natural environments to support and sustain their livelihoods. Social factors such as power structures within villages, local customs, and changes due to socio-economical transformations cannot be ignored when discussing land use, but in a mountainous region where environmental constraints loom large, the natural environment is often the most influential factor on land use decisions. This paper explores the relationships between natural diversity in a mountainous environment and the land use patterns adopted by local inhabitants.

STUDY AREA

The Kingdom of Lesotho is located at about 28–31ºS and 27–30ºE, and lies in the middle of the Drakensberg Mountains in southern Africa. It is a small country (~30,000km^2) that is completely surrounded by the Republic of South Africa. Because about 70% of its land area is above 2,000m altitude, it is also known as the Mountain Kingdom. According to the Köppen Climate Classification, Lesotho has a maritime temperate climate. The region experiences four distinct seasons, with the rainy season falling between November and January (during the summer), and the dry season between June and August (during the winter). The region's vegetation is mainly Highveld grassland or Afromontane scrub forest (White, 1983). The predominant terrestrial formation consists of basalt rock of the Karroo System overlaying a sandstone layer of Permian and Triassic sediments.

Lesotho is less commonly studied than the Ethiopian highlands, even though it is one of most highly populated mountainous areas in Africa, with a population density of 71/km^2 (Lesotho Bureau of Statistics, 2004). The Kingdom was founded in the early 1800s by Sotho-speaking people known as Basotho, who constitute 99% of the population today. This group mainly inhabited the western lowlands originally, but began emigrating to the eastern mountainous region at the end of the 19th century in search of new cultivatable land (Sheddick, 1954). Subsistence in the mountainous region today consists mainly of crop cultivation, pasturage, and the export of migrant work to South Africa.

This study was conducted in Libibing (Fig. 1), a village in the mountainous Mokhotlong District, from September 2005 to March 2006. The altitude of the village ranges from about 2,300m to 2,900m, and a valley lies in the center of the village, in which a river runs from south to north (Fig. 2). The name of the village derives from the Sesotho (the Lesotho Language)word "*seliba*," meaning "spring." According to village elders, there were once many springs throughout the region. However, as the population grew, the number of springs decreased.

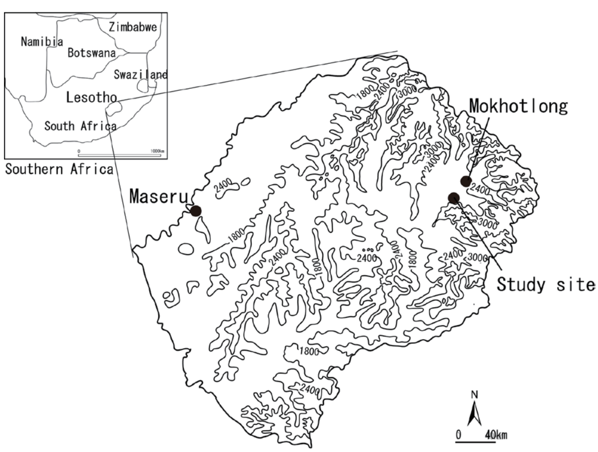

Fig. 1. A topographic map of the kingdom of Lesotho. Contour line drawn every 600m.

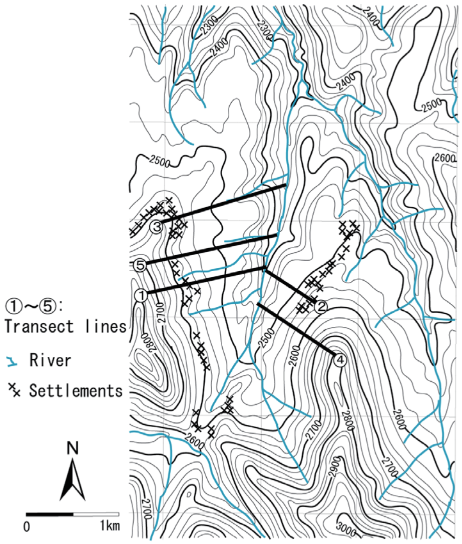

Fig. 2. Locations of transect lines.
Contour line drawn every 250m.

METHODOLOGY

Detailed surveys of the natural environment, including topographic, soil, and temperature characteristics, were conducted, as were interviews with locals.

Topography and sediments

Five transect lines were made: two from the bottom of the valley to the eastern mountain ridges, and three from the valley to the western ridges (Fig. 2). The transect directions were chosen to pass through the greatest slopes. Topographic sectional plans of all transect lines were drawn to detail the topographical patterns and corresponding land use.

Forty-six pits were dug along the transect lines to measure sediment depths, where sediments refer to deposits between the land surface and the underlying bedrock.

Temperatures

Six maximum and minimum thermometers were placed along Transect 1, at altitudes of 2,430m, 2,450m, 2,500m, 2,550m, 2,600m, and 2,700m. Maximum and minimum temperatures were observed at 5:00 am (before sunrise) and at 9:00 am (after sunrise) between November 12, 2005 and February 16, 2006.

Subsistence

Interviews were conducted in English and Sesotho with all 64 households in the village. Data recorded included family structure, field locations, crop types, farming calendar, and the number and type of domestic animals owned. GPS was also used to measure the fields of each household to create a detailed land use map.

SURVEY RESULTS

I. Natural Environmental Factors of the Village

Topography and sediments

The western and eastern borders of the village consist of two mountain ridges extending in a north-south direction. The width of the village across an east-west transect is about 3km. A river flows from south to north through the central valley, which stretches for 2.5km, and the altitude decreases gently from 2,450m at the south end to 2,300m at the north end (Fig. 2). The slope from the summit to the valley bottom is rather stepwise, like a terrace, that flattens out at an altitude of about 2,500m. Below is a summary of the transect survey, using Transect 1 as an example.

Figure 3 shows a cross-section of Transect 1, which is located on the western slope, where the altitude ranges from 2,430m to 2,780m above sea level. The total horizontal distance of the transect is 1,400m. Beginning at the bottom of the valley, there is a gentle incline up to about 50m distance from the starting point (hereafter, DSP); throughout this span, granular to coarse pebble sediments are exposed. The next 150m is dominated by a steep 70m cliff. Coarse pebble- to boulder-sized deposits are exposed along this section. From there (200m DSP), a relatively flat area extends up to about 550m DSP, forming a large terrace; its front edge largely consists of exposed bedrock. At about 550–800m DSP, the terrace is a gentle slope with a predominantly black soil layer. Although there are gullies of about 1m in depth in some places, they did not reach all the way to the bedrock. Then the slope becomes increasingly steep from about 800m DSP until near the summit. At about 2,600m elevation, there are many coarse pebble- to boulder-sized sediments, with some exposed bedrock. The previously observed black soil layer was not present in the upper part of the slope. Springs were observed at altitudes of 2,540m, 2,520m, and 2,500m. Sediment depth was measured at 12 points along the transect (Table 1). The deepest point was at 600m DSP, at the base of the steep incline, where there was a depth of more than 130cm. The shallowest sediments (~10cm) were on the steep slope itself (at 1,300m DSP), and also at the front edge of the terrace (at 300m DSP). Similar topographic characteristics were observed along the other four transect lines.

The development of the sedimentary layers are illustrated in Figures 4 & 5, as histograms of pits that were dug at 50m, 300m, 600m, and 1,300m DSP along Transect 1. At 50m, sediment depth was 53cm. No classification of horizon was observed, soil color was brownish-black (7.5YR3/2), and soil texture was silty loam. The roots of grass and humus were observed. Pebbles up to 5–20mm in size, and stones over 20cm, were also found. At 300m, the sediment depth was 13cm. There was no difference in the horizon, sediment color was brownish-black (10YR2/2), and the

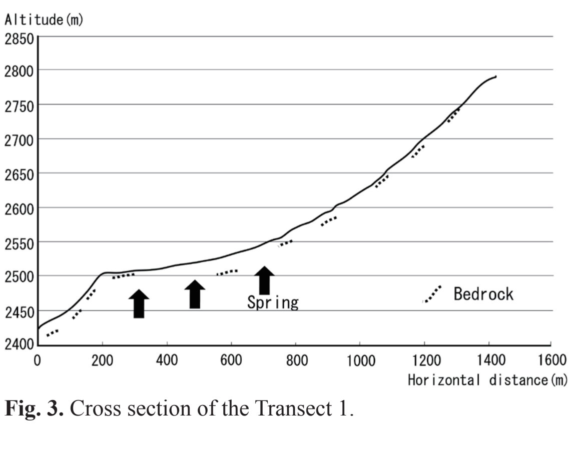

Fig. 3. Cross section of the Transect 1.

Table 1. Soil depths along Transect 1.

Place and Depth		
No.	Horizontal distance (m)	Depth (cm)
1	50	53
2	100	47
3	150	49
4	200	30
5	250	24
6	300	13
7	600	130<
8	800	45
9	900	40
10	1,100	25
11	1,200	33
12	1,300	10

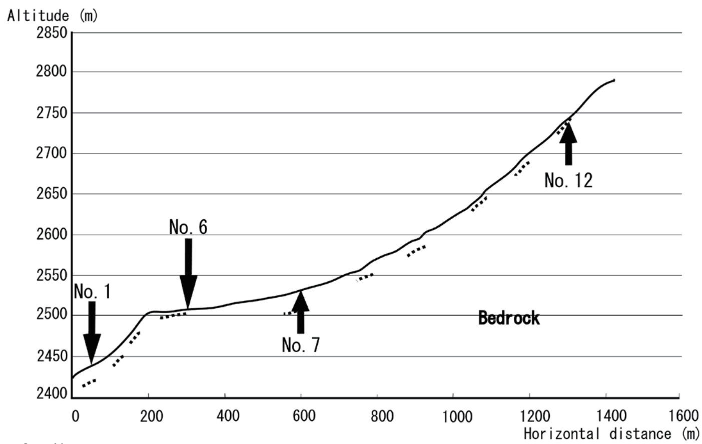

Fig. 4. Points of soil surveys.

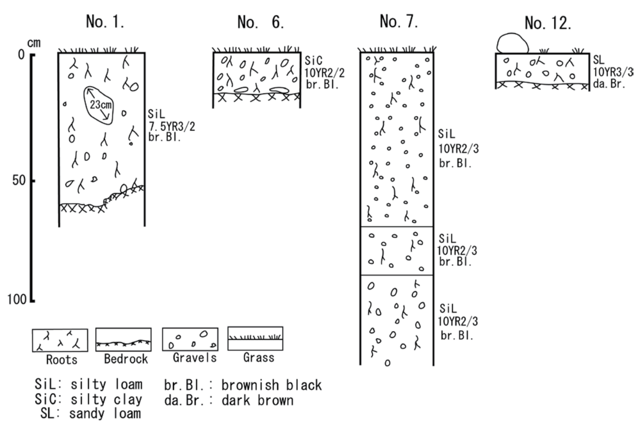

Fig. 5. Soil sections along Transect 1.

texture was silty clay. Roots and humus were observed. Pebbles of about 10mm were present, and weathered rocks were seen close to the bedrock, having been separated from the base. At 600m, sediment depth was 130cm or more. The horizon had three layers. From the surface to 70cm in depth, it was brownish-black (10YR2/3), and was speculated to contain much humus. Soil texture was silty loam, and the sediment contained gravel of about 5mm in diameter or less. Many roots were observed. A layer from 70cm to 90cm in depth was brownish-black (10YR2/3), and contained little humus compared to the first layer. Soil texture was silty loam and contained gravel of 5mm in diameter or less. Few roots were observed. The layer below 90cm was brownish black (10YR2/3), silty loam in texture, and contained fine gravel of 10mm in diameter or less. A characteristic of this sequence of sediments was in the progressive increase in gravel size toward the lower layers. At 1,300m DSP, sediment depth was 10cm. There was no difference in the soil horizon, the soil was dark brown (10YR3/3), and the texture was sandy loam. Gravel of 10mm in diameter or less was present. Although some roots were observed, the soil was not rich in organic matter.

From the five transect surveys, an overall pattern of the village's geographical features can be sketched. Two steep inclines are present, one in the mountain and another in the valley, which are separated at the terrace surface of 2,500m altitude. The steep slope in the valley had the largest inclination, and it is speculated that it was formed by river erosion. Springs were found mainly at the breaking point of the slope, where the steeper mountain slope meets the gentle slope of the terrace. From these results, a classification of the geographic surfaces of the village was made (Fig. 6). Starting from the bottom, the geographic surfaces were named "valley slope," "scarp," "terrace," "talus slope," and "hill slope." Valley slope is a gentle slope extending along the river, and it is presumed to have once been a valley bottom. Sediment in this location is comparatively thick, and the soil is rich in humus. Scarp is a steep

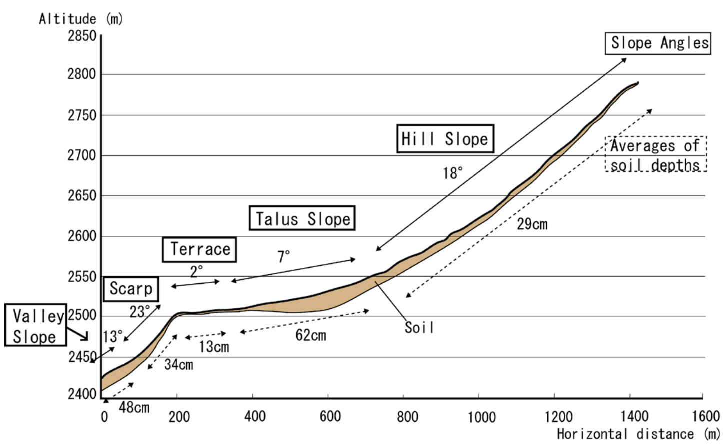

Fig. 6. Different slopes and geographic surfaces.

slope that also extends along the valley. The sedimentary layer in this area is comparatively thin, and coarse pebble- to boulder-sized sediments are found on the surface. Terrace is a relatively flat span with a thin sedimentary layer and bedrock exposure. Talus slope is slightly more inclined than the terrace and includes a geographical feature formed by an accumulation of rocks and debris that have fallen from the mountain slope; the sedimentary layer is very thick with well-developed soil. Finally, hill slope is a steep surface above the talus slope, and includes a thin sedimentary layer of poor soil. There are many coarse pebble- to boulder-sized sediments, some rocks of 30cm in diameter or more, and bedrock exposure.

Temperatures

Table 2 shows the mean maximum and minimum temperatures at each altitude.

Average maximum temperatures in the recorded period were 21.4ºC at 2,430m, 22.1ºC at 2,450m, 23.1ºC at 2,500m, 20.1ºC at 2,550m, 18.9ºC at 2,600m, and 19.4ºC at 2,700 m, indicating that the highest temperature was recorded at 2,500m. This may be due to the exposed bedrock at this altitude, which gets very hot when exposed to sunlight, causing the surrounding air to become significantly warmer. The lowest temperature was recorded at 2,600m, where the temperature was even lower than at the highest altitude of 2,700m, most likely because the temperature rise during the daytime is suppressed due to the location's rich vegetation. The steep slope that starts at 2,700m results in a shallow sedimentary layer, and similar to at 2,500m, heated rocks help elevate the surrounding temperature. The lowest altitude at which temperature was measured was 2,430m, where there was a lower maximum temperature compared to at 2,450m. This may be due to the effect of the river flowing at the bottom of the valley, cooling the surrounding air.

Average minimum temperatures in the recorded period were 9.0ºC at 2,430m, 9.4ºC at 2,450m, 9.5ºC at 2,500m, 8.0ºC at 2,550m, 9.3ºC at 2,600m, and 9.2ºC at 2,700m. The lowest recorded temperature was at 2,550m. The highest minimum temperature was recorded at 2,500m. It is possible that the minimum temperatures recorded at 2,430m and 2,450m were low because cold air had accumulated in the valley during the night. This natural phenomenon, called a

Table 2. Average maximum and minimum temperatures at each altitude.

Altitude (m)	Average Max. Temp. (℃)	Average Min. Temp. (℃)
2,700	19.4	9.2
2,600	18.9	9.3
2,550	20.1	8.0
2,500	23.1	9.5
2,450	22.1	9.4
2,430	21.4	9.0

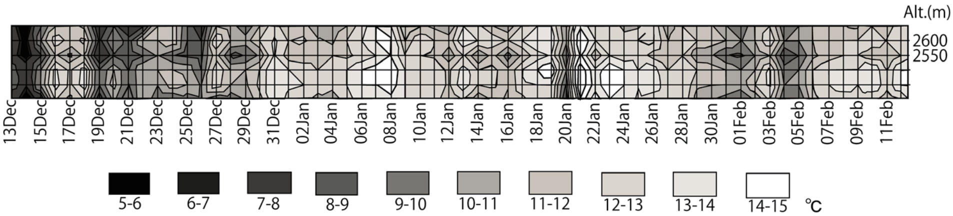

Fig. 7. Vertical profile of air temperature at 5:00 a.m.

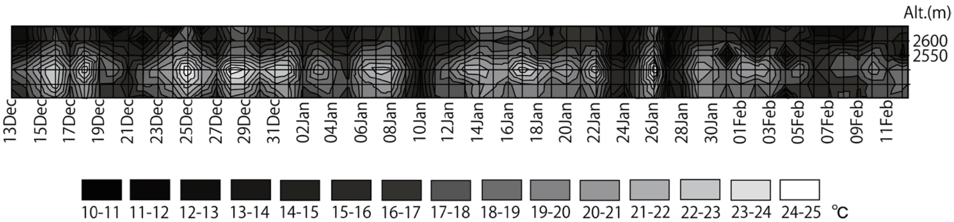

Fig. 8. Vertical profile of air temperature at 9:00 a.m.

cold air lake, is a distinguishing characteristic in this region.

Figure 7 shows an isothermal chart with observation days along the horizontal axis, and altitudes along the vertical axis, and recording temperatures taken at 5:00 a.m. (before sunrise). Many days had distorted isothermal lines around 2,550m. Usually, lower altitude results in a warmer climate, but according to the survey, temperatures at 2,550m above sea level were likely to be colder than those at 2,600m, indicating an inversion layer of temperature at about 5:00 a.m. For example, on December 28, the temperature was 10ºC at 2,600m and 7ºC at 2,550m, which indicates a temperature inversion with a difference of 3ºC. A temperature difference of 3ºC is equivalent to an altitude difference of 500m, assuming a rate of reduction of -0.6ºC per 100m. However, the isothermal chart of observed temperatures at 9:00 a.m. (after sunrise; Fig. 8) shows that the inversion layers that were present at 2,550m have disappeared. It is possible that cold air lakes formed on certain nights, with upper altitudinal limit between 2,550m and 2,600m.

II. Subsistence and Land Use Patterns

Subsistence

The village subsists mainly through crop cultivation and the pasturing of livestock. In February 2006, 84% of the population owned cultivated land, and 46% owned livestock (cattle, sheep, goats, horses, and donkeys). Households without arable land or livestock may similarly benefit by helping other households, and thus the whole village engages in crop cultivation and pasturage. Migrant work is also an important means of income. 24 out of 210 men had been to South Africa for long-term migrant work, primarily as carpenters and field laborers.

Plowing and sowing start when the rainy season is about to begin in September (Fig. 9). The harvest occurs between March and May. Plowing is primarily done by men, who use cattle for assistance, sometimes borrowing the necessary livestock from other households. Women generally do the weeding, with one or a few households participating in the work. Cattle are sometimes used when weeding larger fields (Fig. 10). The cultivated lands of the village were owned by 53 out of 64 households, with each household holding about 24,193m² on average. The remaining 11 households without cultivated lands made a living either by earning cash income or by helping with field labor.

Livestock owned by villagers include cattle, sheep, goats, horses, and donkeys. There is a great range in the number of livestock owned by each household. A total of 29 households owned one or more cattle; 21 owned sheep or goats; 17 owned horses; 8 owned donkeys; and, only 5 owned flocks of more than 20 animals. 32 households did not own any livestock at all. Shepherds are usually teenaged boys. Of the 26 teenaged boys in the village, 9 worked as

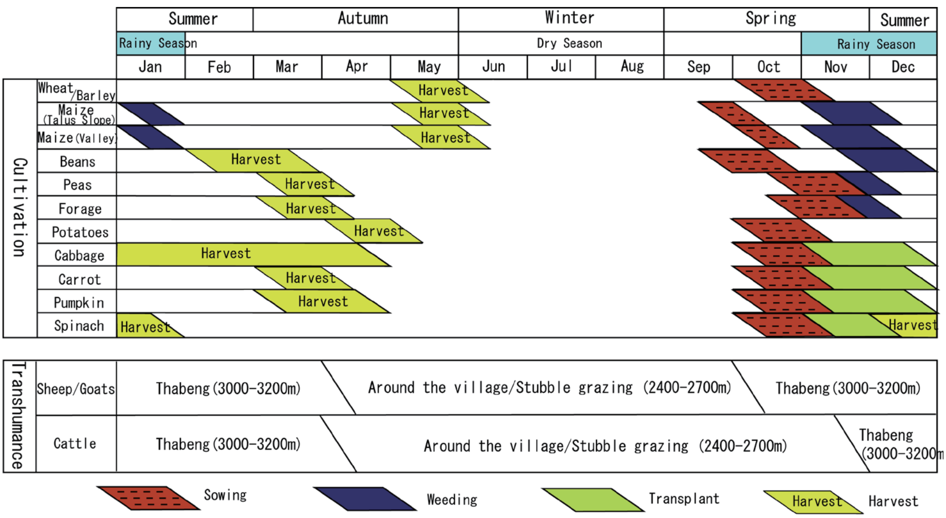

Fig. 9. Agricultural calendar.

Fig. 10. Weeding with cattle.

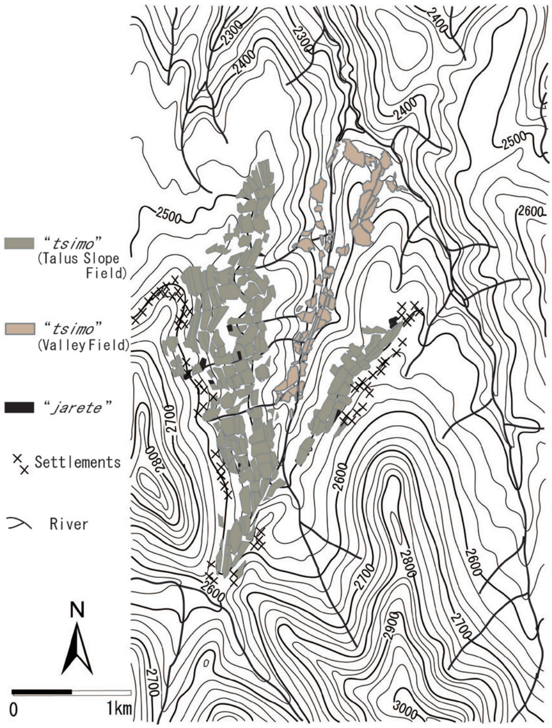

Fig. 11. Land use map.

shepherds, instead of attending school.

Cattle also play other important roles in the village. Beaten cow dung, which is accumulated in the kraal, is regularly used as fuel. Households who do not own cattle collect cow dung from pastures, and use it as fuel. As woody vegetation is very scarce in the area, cow dung is an important fuel for the villagers. Cattle are also used as bride price, and are consumed as part of traditional funerals. As a result, cattle represent more than just livestock to the local people (Turkon, 2003). Wool and mohair are exported once or twice a year to South Africa, generating a significant cash income. Sheep and goats are also slaughtered for special feasts. Horses and donkeys are primarily raised for transportation.

Because the village uses a multiple subsistence system of crop cultivation and pasturage, this study divided the land use of the study area into three main categories: settlements, cultivated lands, and pasture. In the next section, each land use category is explained.

Settlements

The village includes five settlements, each of which consists of blood relatives. All five settlements are located at the same altitude, about 2,600m (Fig. 11).

Houses are constructed of thatched roofs and stone walls. Cultivated wheat and barley are used for building straw roofs, and stones are gathered from the hillslopes. The frameworks of roofs are made of shafts of *Populus* spp., which are brought in from outside the village. The ground is flattened, then, stones are piled into the shape of a circle to construct a wall. Mud and pebbles are used as a cement to bond the stones together. After the roof framework is finished, it is thatched with straw.

A new hut is usually built for a newly married couple, or when a family grows too large for a hut.

Cultivated lands

There are two types of cultivated land: one for growing vegetables such as cabbage, tomatoes, spinach, and radish, and another for growing staple foods such as maize, barley, and wheat, as well as various non-staples such as peas, beans, and potatoes. The former is known as *jarete* and the latter as *tsimo* in Sesotho.

In the village, people started to cultivate *jarete* after the 1990s, to supplement their income by growing and selling vegetables for cash. According to interviews, the resulting cash flow was used to purchase necessities such as soap and matches. All *jarete* plots are located on the talus slope (Fig. 12).

Tsimo is primarily grown in two different places: on the terrace at about 2,500m altitude (talus slope), and in the valley (Fig. 11). On talus slopes, they grow barley, wheat, maize, and peas, while maize and beans predominate in valley fields. Different crops are cultivated in each field (Fig. 13). Maize is mostly grown in the valley, and barley and wheat are mostly grown on the talus slope. For example, maize was grown in 73% of valley fields in 2005, followed by beans, sorghum, and wheat. Wheat was grown only by one household. In talus slope fields, barley and wheat were grown on more than

Fig. 12. Vegetables grown in the “*jarete*”.

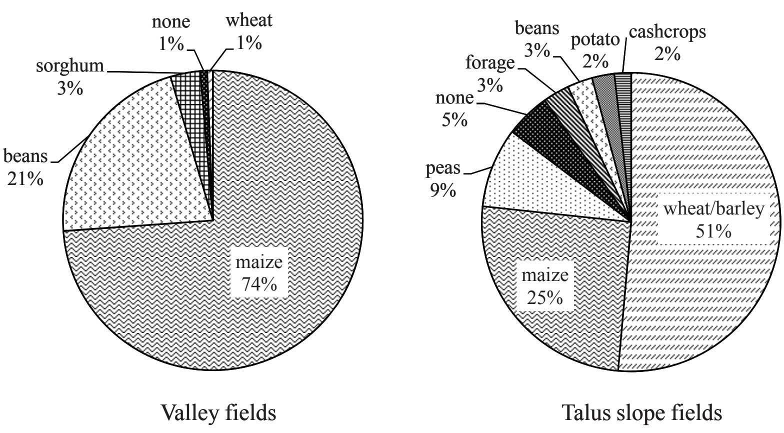

Fig. 13. Different crops grown in the two “*tsimo*”.
% are area ratios. Total area: Valley fields = 27.2ha, Talus slope fields = 112.5ha.

50% of the area, followed by maize, peas, forage, beans, potatoes, and cash crops (vegetables). According to the villagers, valley fields are too hot to be suitable for growing barley and wheat, but are well suited to growing maize. The weather is, however, considered cool enough for barley, wheat, and peas to grow well on the talus slope.

Pasture

The grazing areas for sheep, goats, and cattle vary from season to season (Fig. 9). In the summer, animals are sent to high mountain ranges 3,000m or higher in altitude (*thabeng*), about 30km from the village. This transhumance begins at the same time as the sowing of the crops. In *thabeng*, there are huts, called *motebo* in Sesotho, where shepherds sleep. Sheep and goats are sent to *thabeng* one and a half months earlier than cattle, and are brought back down to the village in April, when the harvest is about to begin. During the autumn and winter, the agricultural off-season, they graze around the village during the day, and are brought back to kraal in the evening. After the harvest, they browse on the stems and leaves of maize that are left behind in the fields. Households that own livestock often store them for this purpose, or grow other forage.

LAND USE PATTERNS AND THE NATURAL ENVIRONMENT

This section examines the relationship between the natural environment and land use in the village. As illustrated in Figure 14, each form of land use (settlements, cultivated fields, and pastures) corresponds to the geography patterns described in previous sections.

Settlements and the environment

Settlements are located between the hill slope grazing land and the talus slope, and along the 2,600m contour line. This is the breaking point of the slope between the steep hill slope and the gentle talus slope, near the site of several springs. This area has shallow soil depth of 20–40cm (28cm on average). When a house is built, a ditch of about 30cm in depth is dug in a circle for the foundation of the wall. Additional soil is placed on the slope to level the ground, implying that the original soil depth is not a limiting factor in building houses.

The settlements are located at about 2,600m altitude, and therefore avoid the more extreme temperatures created by the cold air lake that forms at night around 2,550m altitude (Fig. 15). This area is also kept cool during the daytime, so the diurnal temperature range here is the smallest in the study area.

Cultivated fields and the environment

Fields in both the valley and on the talus slope lie immediately below a steep slope. Soil depth on the talus slope ranged from 40cm to more than

130cm, with an average depth of 62cm. Valley soil ranged from 30 to 65cm, with an average depth of 48cm. These two areas had the deepest sediments throughout the study site. There was a great deal of rubble in the sediment, some rocks measuring more than 20cm in diameter; this was likely due to the accumulation of sand and pebbles that had fallen from the steep slope above.

The villagers report that the valley is too hot for barley and wheat to grow. An examination of the temperature difference between the talus slope and valley fields showed that the valley field experiences markedly higher temperatures (both maximum/minimum temperatures and average temperature; Table 3). For example, the average difference in maximum temperatures between talus slope and valley fields was about 2ºC, and greater than 4ºC on some days, as shown in Table 3. Further surveys are needed to explore parameters such as rainfall, humidity, and wind to clarify the influence of temperature differences on these two types of fields.

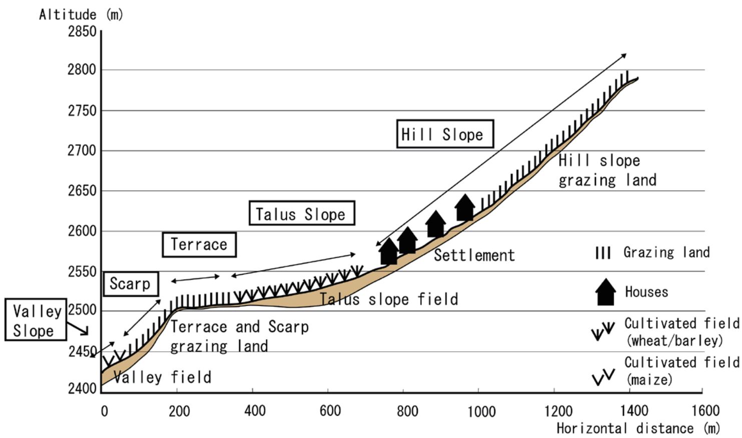

Fig. 14. Relation between land use and the geographic surfaces.

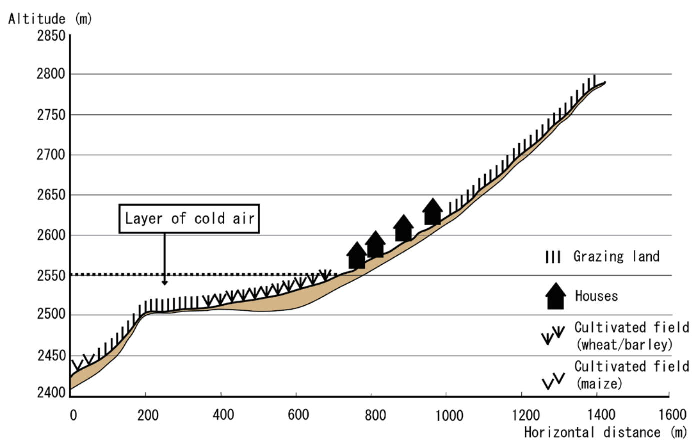

Fig. 15. Higher limit of the cold air lake.

Table 3. Temperature differences between the two fields.

	Avgerage Temp. (℃)	Avgerage Min. Temp. (℃)	Max. Temp. (℃)		
			Average	14 Nov.	28 Dec.
Talus slope field	13.7	8.0	20.1	20.0	20.0
Valley field	15.6	9.5	22.2	24.3	24.5
Difference	1.9	1.5	2.1	4.3	4.5

Pastures and the environment

The hill slope, terrace, and scarp are all used for pasture, where outcrops and gravel beds are abundant over the surface, and the soil depth is relatively shallow. The grade of the slope is 2° in the terrace grazing land, but 18° in the hill slope grazing land and 23° in the scarp grazing land. The soil depth was 10–47cm (29cm on average) along the hill slope, 10–24cm (13cm on average) on the terrace, and 15–50cm (34cm on average) on the scarp. Each had generally shallow sediment. The villagers believe that such land is not suitable for cultivation, so they use it for pasture.

The hill slope, terrace, and scarp areas exhibit different temperature characteristics as well. The hill slope (2,700m) had the second lowest maximum temperature of the day (19.4ºC), followed by settlements (2,600m). In other words, although the hill slope is 100m higher in altitude than the settlements, its maximum temperature was higher. This was probably because the hill slope has more exposed outcrops, allowing the sun to heat the ground, while in the settlements grass and other plants prevent the temperature from rising drastically during the day. The hill slope had the third lowest minimum temperature, despite being at the highest altitude. This may be due to the formation of a cold air lake in some nights in lower altitudes.

The terrace grazing land (2,500m) had the highest maximum temperature of 23.2ºC, and the diurnal temperature range was the greatest here among the six surveyed sites. The high temperatures here can be attributed to the exposed outcrops being heated by the sun. The maximum temperature in scarp areas was 22.2ºC, the second highest after terrace grazing land.

CONCLUSION

Settlements tend to be located along the 2600m contour line, and the local population practice distinct land use patterns.

Land with thick soil appropriate for cultivation is limited in this mountainous area, and thus cultivation is restricted to a gentle slope region where the soil layer is thickest. A steep slope that is unsuitable for cultivation is used as pasture. The settlements are located between cultivated lands and pastures, allowing villagers to observe both crops and livestock simultaneously. As a 60-year-old woman reported, “Our grandfathers used to graze animals in the hill slope, and cultivate fields in the flat surface. Houses were located in between them so that they could go to either of them easily.”

But if accessibility to the fields and livestock were the only factor contributing to the location of the settlements, the villagers could have built houses in the terrace area as well, between the talus slope and the scarp grazing lands. Indeed, Basotho huts have been reported to be “perched on the edge of a cliff or crowning a hillock in the open plain.” (Sheddick, 1954: 52), and the village surveyed in the present study does not conform to this observation. Another possible contributor to the location of the settlements is the proximity of the site to a water source. There are springs not only around the settlements but also on the terrace. Water from the springs of the terrace runs down the slope due to a lack of impeding soil depth. However, springs close to the settlements form ponds where the soil depth of the area is deeper and villagers are able to make a reservoir. Today, as water taps have been introduced, springs are used only in times of emergency when the taps are broken. Regardless, it is certain that ready access to water was a deciding factor in the location of the original settlement. As a result, the location chosen was a climatically pleasant place where the populace can avoid the extreme cold of cold air lake formation.

The environmental factors of the region contributed strongly to the decisions made by locals about land use. Indeed, the natural environment appears to be one of most important factors contributing to land use patterns, but further studies are required to clarify the extent of this influence.

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